Report Y/MA-6400

THE CHEMICAL AND RADIOLOGICAL CHARACTERIZATION OF THE S-3 PONDS

July 14,1983

Y-12 Plant
Operated by
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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1.0 INTRODUCTION

The Y-12 Plant has been characterizing the chemical composition of the S-3 ponds since 1962. References 1 and 2 (Y/DA-7794, Chemical Analysis of the S-3 Disposal Ponds; Y/DZ-12, 1981 Analysis of S-3 Ponds) include comparative data for the years 1962, 1975, 1978, and 1981. These characterizations led us to recognize the need to discontinue use of the S-3 ponds, which we proposed in 1973, and to begin construction of a pollution control facility.

The 1983 data reported here in response to Section IV, Item 2a of the DOE-EPA-TDHE Memorandum of Understanding (MOU) continue to confirm our need for the treatment facility to handle other liquid wastes, although we have made progress in reducing nitrate waste through our recovery, neutralization and biodegradation efforts. Total nitrate contents of the S-3 disposal ponds by year are shown in Table 7.

2.0 DISCUSSION

The S-3 ponds located at the far west end of the Oak Ride Y-12 Plant site (Figure 1) have been collecting liquid wastes from the operations of the Plant for about 32 years. They were originally constructed to collect waste nitric acid and other nitrate wastes. The current overall pH values are generally less than 2.0 and nitrate ion concentrations ranges from 6700 ppm to 85000 ppm. Current plant operations have tended

to reduce the amount of waste acids entering the four originally interconnected pools of the S-3 ponds, and to increase the amount of other waste solution contributions, the latter containing small quantities of soluble metals and some small quantities of organics. The Southwest Pond now undergoing experimental denitrification is isolated from the other three ponds. The current total annual quantity of liquid wastes entering the ponds is estimated to be approximately 2.7 million gallons. Rainfall adds four to six million gallons each year, depending upon annual rainfall. The nominal volume of all four pools is ten million gallons, each pool containing about 2.5 million gallons. Evaporation losses are calculated to be about 3 million gallons per year, based on Department of Commerce, National Oceanic and Atmospheric Administration Data. The ponds have never overflowed nor have they ever gone dry, but levels have fluctuated from season to season and year to year.

3.0 SAMPLING PROCEDURE

Samples of the S-3 ponds were taken on June 7, 8, and 9, 1983. The ponds have been designated as the Northeast, Southeast, Northwest, and Southwest ponds (see Figure 2). The Southwest Pond is currently under experimental treatment by the Y-12 Development Division to obtain data on the in-situ denitrification of this pond by biological techniques. Liquid and sediment samples obtained from this pond are, therefore, representative of impurities present after neutralization was started.

The approximate location of aqueous and sediment samples taken from each pond to prepare the composite sample analyzed by the Y-12 Laboratory are presented in Figure 2. The aqueous phase of each pond was sampled at the designated locations at upper and lower levels. In addition, sediment samples were removed from the bottom of each pond at the same locations.

The uppermost aqueous layer of each pond was sampled by attaching a weighted one-liter sample bottle to a float which filled on sinking approximately twenty centimeters beneath the pond surface. The lower aqueous layer of each pond was sampled by using a weighted one-liter sample bottle heavy enough to quickly sink to the bottom where the air was displaced with pond solution. Sediment samples from each pond were taken by dredging the pond bottom with a heavy stainless steel pipe, one foot in length, three inches in diameter and closed at one end, which filled with solids as it moved along the pond bottom.

4.0 DISCUSSION OF DATA

4.1 Aqueous Phase

A compilation of chemical analyses of the composited upper and lower aqueous samples for each pond is presented in Table 1. The uppermost aqueous samples taken from each pond were composited to result in the single value reported and the lower level samples from each pond were likewise composited to result in the single value shown.

The radioactivity associated with the S-3 disposal ponds solutions is compiled in Table 2.

The isotopic analysis of the uranium found in each pond is indicated in Table 3 and reveals that the isotopic assay of the uranium is basically depleted (99.6% ^{238}U).

4.2 Solid Phase

A compilation of the chemical data obtained from the sediment samples of each pond is listed in Table 4. The samples taken from each pond bottom were composited to represent the values reported. (See Figure 2.)

The radioactivity associated with the sediment from each pond is presented in Table 5. The uranium isotopic ratios of the uranium found in the pond sediments are summarized in Table 6.

5.0 REFERENCES

1. Jeter, I. W., Napier, J. M., Chemical Analysis of the S-3 Disposal Ponds (April, 1978), Union Carbide Corporation-Nuclear Division, Oak Ridge, Tennessee. Report No. Y/DA-7794, August 11, 1978.

2. Saunders, M. B., Napier, J. M., 1981 Analysis of S-3 Ponds, Union Carbide Corporation-Nuclear Division, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee. Report No. Y-DZ-12, December 21, 1981.

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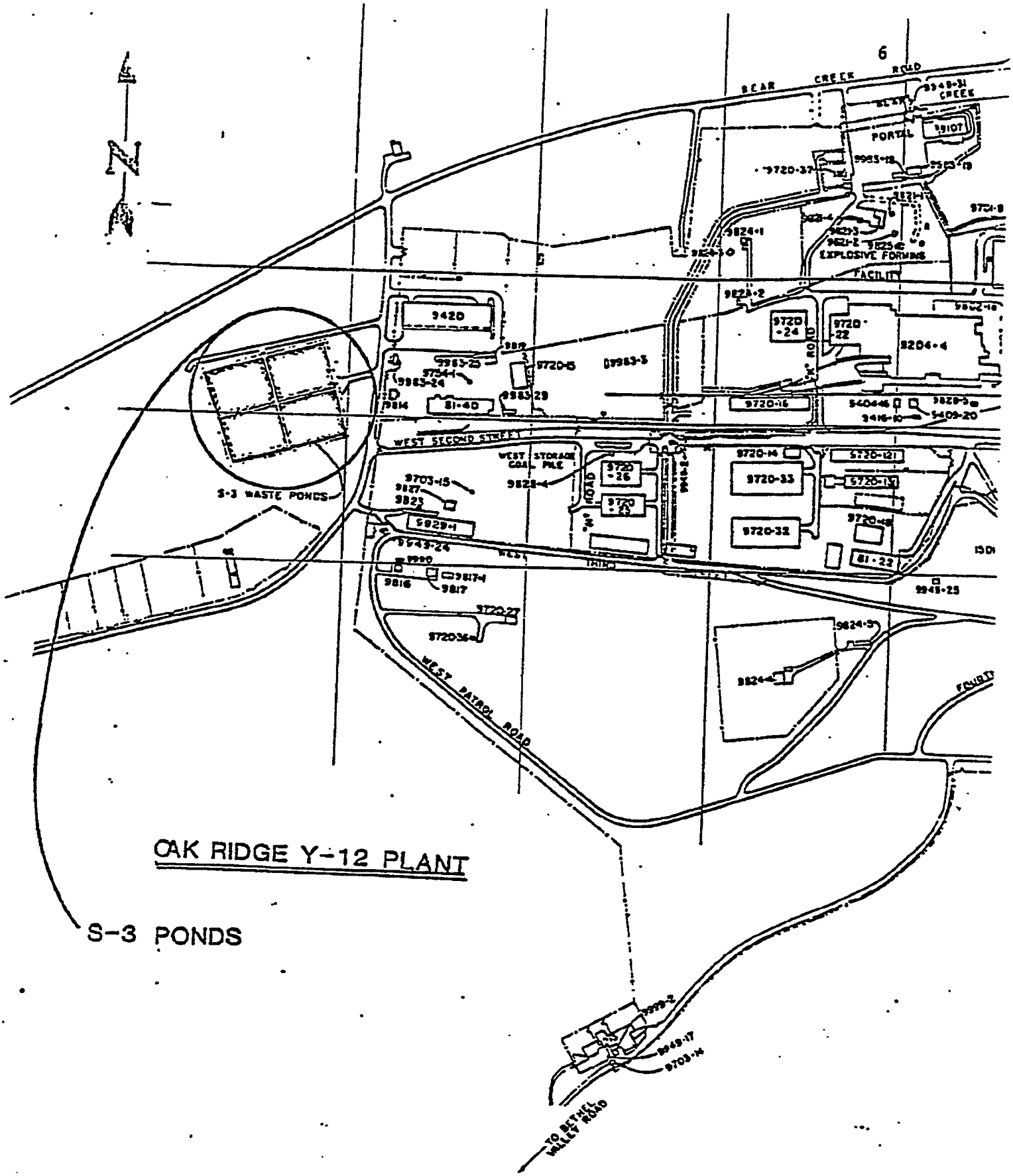
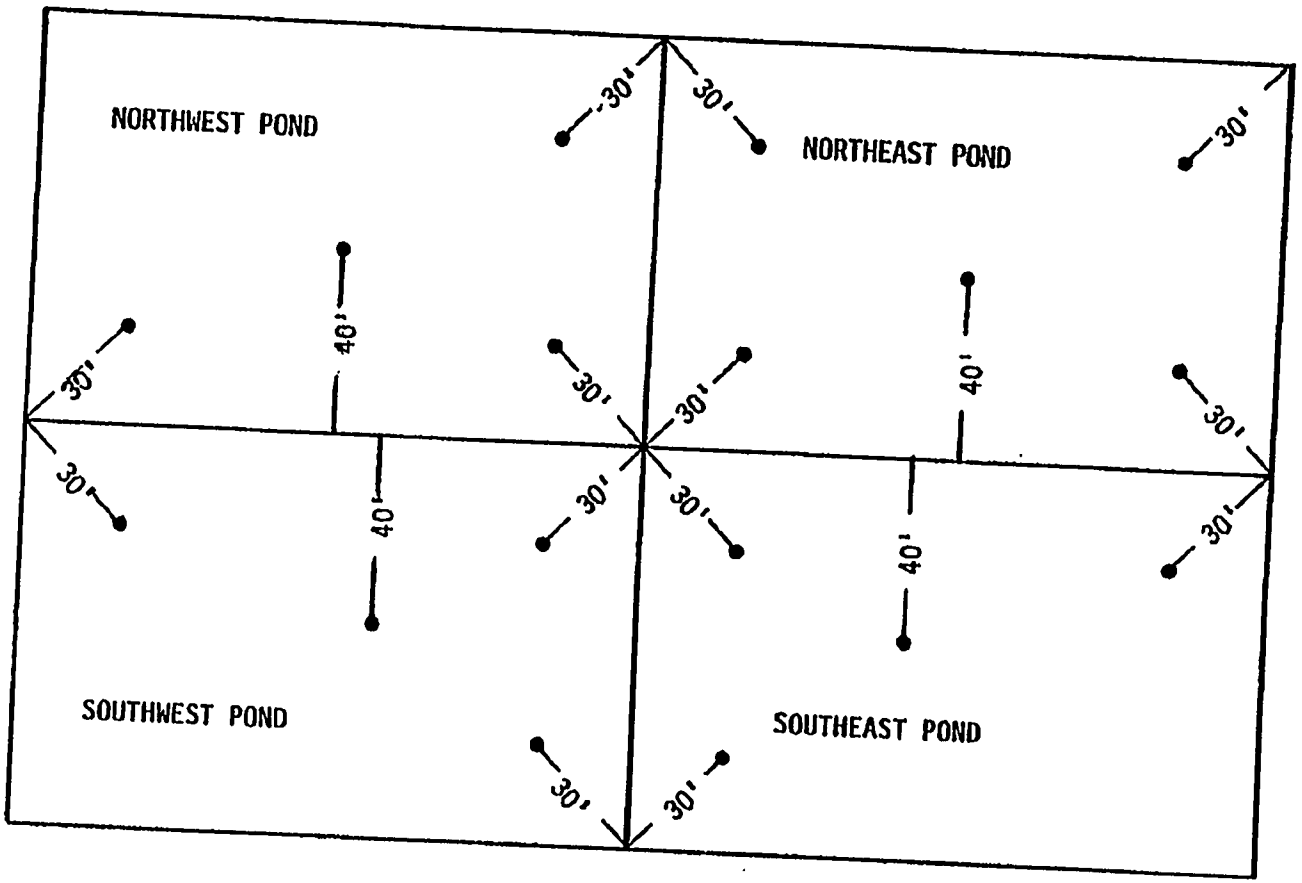


FIGURE1: S-3 SITE LOCATION



● = LOCATION OF (1) BOTTOM SEDIMENT SAMPLES
(2) UPPER LEVEL AQUEOUS SAMPLES
(3) LOWER LEVEL AQUEOUS SAMPLES

FIGURE 2. S-3 POND SAMPLING POINTS

TABLE 1

ANALYSES OF THE S-3 DISPOSAL PONDS AQUEOUS PHASE

Values are Milligrams Per Liter of Solution Except for pH and Specific Gravity Values

	Southeast Pond		Northeast Pond		Southwest Pond		Northwest Pond	
Test(1)	Upper (Mg/L)	Lower (Mg/L)	Upper (Mg/L)	Lower (Mg/L)	Upper (Mg/L)	Lower (Mg/L)	Upper (Mg/L)	Lower (Mg/L)
pH	2.4	3.0	0.9	0.54	4.9	6.4	1.1	0.94
Sp.G.	1.0000	1.0098	1.0191	1.0624	1.0074	1.0069	1.0085	1.0402
NO_3(2)	6,700	16,000	30,000	85,000	8,400	8,700	19,000	52,000
Cl(8)	190	270	600	1,000	300	330	480	1,000
Perc(3)	None Detected	2	4.0	21	None Detected	None Detected	1	7
PCB(4)	<0.0005	0.017	0.0031	0.0072	(7)	(7)	<0.0005	<0.0005
U(5)	33	74	137	600	26	52	100	400
Ag	<0.02	0.05	0.032	0.35	<0.02	<0.02	0.021	0.08
Al	435.3	1,291.5	1,653.2	4,108	288.4	788.5	1,163.0	4,410
As	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
B	3.8	4.4	9.7	16.7	5.5	6.2	8.34	10.1
Ba	0.26	1.9	0.65	5.7	0.48	1.1	0.46	1.0
Be	0.03	0.06	0.04	0.03	0.05	0.10	0.03	0.11
Ca	549.9	2,087.9	451.6	1,468.5	2,053.0	3,059.2	395.0	696.2
Cd(6)	0.19	0.42	0.64	1.1	0.21	0.27	0.49	2.2
Ce	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
Co	0.12	0.19	0.35	0.51	0.19	0.26	0.30	0.85
Cr	2.9	5.8	17.97	23.8	2.5	6.2	12.3	24.1
Cu	3.9	8.8	16.8	39.4	2.6	6.1	11.9	27.7
Fe	39.6	100.5	381.9	274.2	23.5	62.0	354.4	662.3
Ga	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Hf	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	<0.1
Hg(6)	<0.001	0.1	0.17	0.62	0.005	0.064	0.082	0.18
K	37.7	54.8	71.6	124.2	70.0	69.5	70.2	322.4
La	0.005	0.02	0.0017	0.04	<0.001	0.002	0.004	<0.001
Li	4.5	8.2	11.9	34.5	6.7	8.1	8.4	19.1
Mg	87.3	166.4	182.8	335.1	111.0	138.8	157.6	288.2
Mn	3.0	4.7	7.4	10.2	3.9	5.5	6.8	17.7
Mo	0.25	0.83	1.2	1.7	0.22	0.82	0.84	1.9

TABLE 1 (Cont'd)

ANALYSES OF THE S-3 DISPOSAL PONDS AQUEOUS PHASE

Values are Milligrams Per Liter of Solution Except for pH and Specific Gravity Values

	Southeast Pond		Northeast Pond		Southwest Pond		Northwest Pond	
Test(1)	Upper (Mg/L)	Lower (Mg/L)	Upper (Mg/L)	Lower (Mg/L)	Upper (Mg/L)	Lower (Mg/L)	Upper (Mg/L)	Lower (Mg/L)
Na	519.3	796.8	988	1,724	1,892	2,638	854	1,958
Nb	0.02	0.25	0.007	0.82	0.08	0.18	0.008	0.06
Ni	21.5	32.4	50.9	72.3	33.7	55.4	43.4	55.8
P	5.2	29.3	65.3	86.4	6.5	24.8	35.3	51.2
Pb	0.53	1.6	4.8	14.5	0.26	1.2	2.6	4.0
Sc	<0.003	0.01	0.019	0.03	0.003	0.01	0.015	0.15
Se	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Si	0.08	4.3	0.13	7.0	2.5	2.0	0.64	<0.01
Sr	0.70	1.6	1.6	4.1	1.2	1.9	1.1	3.0
Th	0.70	2.2	7.1	12.2	0.39	0.01	7.0	62.6
Ti	0.13	0.79	1.5	3.9	0.04	0.35	1.0	4.6
V	<0.02	0.04	0.18	0.09	<0.02	0.04	0.15	1.0
Y	0.11	0.29	0.089	0.32	0.07	0.19	0.07	0.16
Zn	3.2	6.1	8.3	14.1	3.2	5.9	6.2	10.1
Zr	0.08	2.6	0.45	32.7	0.45	0.81	0.41	3.9

(1)Spectrographic results by Inductively Coupled Plasma (ICP) Spectrometry unless otherwise noted.

(2)Nitrate concentration determined by ultraviolet spectrophotometry.

(3)Perchloroethylene (tetrachloroethylene) determined by gas chromatography.

(4)PCB analysis by gas chromatography.

(5)Uranium concentration determined by mass spectrometry.

(6)Cadmium, mercury, and selenium concentrations determined by atomic absorption.

(7)Insufficient Sample

(8)Chloride analysis by specific ion electrode method

TABLE 2

RADIONUCLIDE ANALYSES OF THE S-3 DISPOSAL POND

AQUEOUS PHASE

Radionuclide(1)	Southeast Pond		Northeast Pond		Southwest Pond		Northwest Pond	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Alpha								
^{241}Am (pCi/ml)	0.30	0.20	0.30	1.00	<0.20	0.30	0.30	0.60
^{238}Pu(pCi/ml)	0.04	0.31	0.84	1.65	0.05	0.06	0.25	3.42
$^{239, 240}Pu$(pCi/ml)	0.07	0.45	0.73	0.44	0.18	0.10	0.25	1.60
^{237}Np (pCi/ml)	0.84	1.80	2.20	6.60	0.74	0.97	1.13	2.60
Total Alpha Activity (pCi/ml)	29	110	160	590	45	70	160	180
^{238}Pu (gms)(2)	1.72×10^{-5}	1.34×10^{-4}	3.6×10^{-4}	7.1×10^{-4}	2.72×10^{-5}	3.26×10^{-5}	1.36×10^{-4}	1.86×10^{-3}
^{239}Pu (gms)(2)	0.0086	5.5×10^{-2}	9.17×10^{-2}	5.38×10^{-2}	2.78×10^{-2}	1.54×10^{-2}	0.038	0.25
^{237}Np (gms)(2)	8.91	19.10	23.35	70.04	9.91	12.58	15.10	34.80
^{241}Am (gms)(2)	6.9×10^{-4}	4.62×10^{-4}	6.93×10^{-4}	2.31×10^{-3}	(3)	8.74×10^{-4}	8.74×10^{-4}	1.75×10^{-3}
Beta								
Total Beta (pCi/ml)	69	190	230	840	58	110	200	280
^{99}Tc (pCi/ml)	20	97	81	134	20	31	64	45
^{99}Tc (gms)(2)	9.00	43.70	36.50	60.30	11.40	17.60	36.30	25.50

TABLE 2 (Continued)

RADIONUCLIDE ANALYSES OF THE S-3 DISPOSAL POND

AQUEOUS PHASE

Radionuclide(1)	Southeast Pond		Northeast Pond		Southwest Pond		Northwest Pond	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Total Gamma Activity (μCi/ml)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
^{137}Cs (μCi/ml)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
^{95}Zr-Nb (μCi/ml)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
^{106}Ru (μCi/ml)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

(1)Activity analyses by radiochemical techniques.
(2)Total grams contained in each pond based on specific activity of isotope noted.
(3)Insufficient Sample

TABLE 3

URANIUM ISOTOPIC ANALYSIS OF THE S-3 DISPOSAL POND(1)

AQUEOUS PHASE

	Assay (Weight Percent)							
	Southeast Pond		Northeast Pond		Southwest Pond		Northwest Pond	
Nuclide	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
^{235}U	0.39	0.43	0.34	0.30	0.33	0.34	0.40	0.3
^{238}U	99.60	99.50	99.60	99.70	99.70	99.60	99.60	99.70

(1)Uranium assay determined by Thermal Emission Ion Counting Mass Spectrometry

TABLE 4

ANALYSIS OF THE
S-3 DISPOSAL POND SEDIMENTS(1)

Test	Southeast Pond (µg/g)	Northeast Pond (µg/g)	Southwest Pond (µg/g)	Northwest Pond (µg/g)
Ag	7.3	17.0	2.1	4.1
Al	41,897.8	41,854.0	59,034.9	21,643.8
As	14.8	32.5	26.0	21.7
B	70.0	98.7	138.6	55.7
Ba	359.4	428.6	285.9	337.3
Be	16.4	1.3	2.9	1.4
Ca	3,962.9	1,005.5	1,952.2	894.3
Cd	<0.6	<0.6	<0.6	<0.6
Ce	48.0	45.9	73.3	72.3
Co	3.3	1.6	1.4	<0.01
Cr	163.9	75.9	135.1	48.5
Cu	145.3	136.4	111.1	128.2
Fe	92,031.0	89,500.0	26,284.2	8,232.8
Ga	11.9	1.6	33.5	30.5
Hf	19.4	4.9	14.3	14.0
Hg	12.0	1.7	0.88	0.21
K	8,000.3	11,070.6	23,762.6	8,307.9
La	25.5	37.7	42.1	45.7
Li	46.3	46.9	35.1	29.2
Mg	2,341.1	2,614.7	4,437.0	1,593.7
Mn	112.0	108.1	63.1	45.9
Mo	191.7	103.8	113.7	30.1
Na	1,429.5	1,768.9	1,993.5	2,041.0
Nb	136.8	62.0	30.9	75.6
Ni	98.8	73.9	60.6	62.9
P	6,896.4	1,333.5	2,454.8	2,296.9
Pb	119.7	198.1	155.0	207.0
Sc	5.6	8.1	8.4	4.6

TABLE 4 (Cont'd)

ANALYSIS OF THE
S-3 DISPOSAL POND SEDIMENTS[1]

Test	Southeast Pond (µg/g)	Northeast Pond (µg/g)	Southwest Pond (µg/g)	Northwest Pond (µg/g)
Se	<0.2	<0.2	<0.2	<0.2
Si	40.9	37.5	666.0	22.7
Sr	40.3	46.0	62.3	66.5
Th	271.7	150.0	196.0	529.4
Ti	3,630.5	5,172.1	5,120.1	5,206.1
U	620.0	280.0	410.0	300.0
V	63.1	61.5	64.7	26.5
Y	8.4	12.5	12.1	11.6
Zn	91.2	95.0	56.3	34.0
Zr	1,472.0	817.7	1,077.4	3,366.0

(1)All Values in Micrograms Per Gram of Dry Solids. Results obtained by Inductively Coupled Plasma (ICP) Method.

TABLE 5

RADIONUCLIDE ANALYSES OF THE S-3 DISPOSAL POND SEDIMENT (1)

Radionuclide	Southeast Pond	Northeast Pond	Southwest Pond	Northwest Pond
Alpha				
^{238}Pu (pCi/g)	39	89	90	174
$^{239,\ 240}Pu$ (pCi/g)	18	34	65	42
^{241}Am (pCi/g)	<1.7	<1.7	<1.7	<1.7
^{237}Np (pCi/g)	5.1	2.5	2.0	3.2
Total Alpha Activity (pCi/g)	3,263	923	795	1,317
Beta				
^{99}Tc (pCi/g)	6,388	140	96	73
Total Beta Activity (pCi/g)	7,892	680	466	994
Gamma				
^{137}Cs (μCi/g)	<0.001	<0.001	<0.001	<0.001
^{95}Zr-Np (μCi/g)	<0.001	<0.001	<0.001	<0.001
^{106}Ru (μCi/g)	<0.001	<0.001	<0.001	<0.001
Total Gamma Activity (μCi/g)	<0.001	<0.001	<0.001	<0.001

(1)Activity analyses by radiochemical techniques

TABLE 6

URANIUM ISOTOPIC ANALYSIS

OF THE S-3 DISPOSAL POND SEDIMENT(1)

Nuclide	Assay (Weight Percent)			
	Southeast Pond	Northeast Pond	Southwest Pond	Northwest Pond
^{235}U	0.52	0.62	0:37	0.49
^{238}U	99.50	99.40	99.60	99.50

(1)Uranium Assay determined by Thermal Emission Ion Counting Mass Spectrometry.

TABLE 7

TOTAL NITRATE CONTENT OF

S-3 DISPOSAL PONDS BY YEAR

YEAR	NITRATE CONTENT (Kilograms)
1962(1)	2,263,000
1975(1)	1,866,000
1978(1)	993,000
1981(1)	581,000
1983	978,000(2)

(1) From Reference 2

(2) Due to increase in plant production and temporary shut-down of Y-12 plant denitrification facility.